

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : F01L 1/24, 1/18, 1/053	A1	(11) International Publication Number: WO 00/20730
		(43) International Publication Date: 13 April 2000 (13.04.00)

(21) International Application Number: **PCT/IB99/01699**
 (22) International Filing Date: **5 October 1999 (05.10.99)**

(30) Priority Data:
 MI98A002136 5 October 1998 (05.10.98) IT

(71) Applicant (for all designated States except US): **EATON AUTOMOTIVE S.P.A. [IT/IT]; Via Bicocca, 28, I-10086 Rivarolo Canavese (IT).**

(72) Inventor; and
 (75) Inventor/Applicant (for US only): **CECUR, Majo [IT/IT]; Corso Indipendenza, 31, I-10086 Rivarolo Canavese (IT).**

(74) Agents: **BURKE, Steven, D. et al.; R.G.C. Jenkins & Co., 26 Caxton Street, London SW1H 0RJ (GB).**

(81) Designated States: **BR, JP, US, European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).**

Published

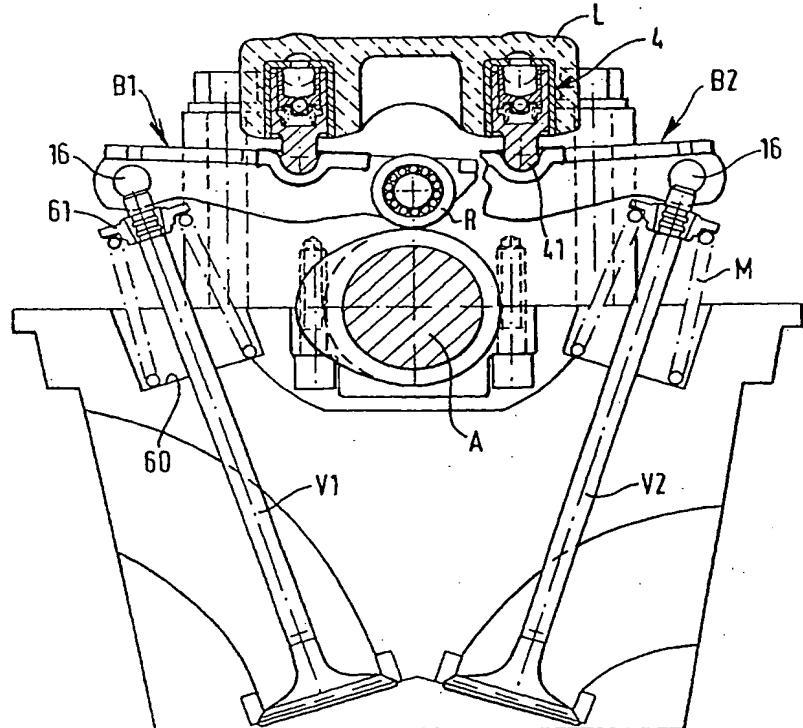
With international search report.

Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: **VALVE TRAIN ASSEMBLY**

(57) Abstract

A valve train assembly for an internal combustion engine comprises a common carrier which supports the engine's rocker arms by means of individual fulcra each of which preferably forms a part of a hydraulic lash adjuster. Each rocker arm is constructed by deforming a metal sheet into a channel shape, the deformation also forming a part-spherical surface for mating with a surface of the fulcrum. The rocker arms can be snap-fitted on to the fulcrum by means of an apertured, resilient sheet.



FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece	ML	Mali	TR	Turkey
BG	Bulgaria	HU	Hungary	MN	Mongolia	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MR	Mauritania	UA	Ukraine
BR	Brazil	IL	Israel	MW	Malawi	UG	Uganda
BY	Belarus	IS	Iceland	MX	Mexico	US	United States of America
CA	Canada	IT	Italy	NE	Niger	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NL	Netherlands	VN	Viet Nam
CG	Congo	KE	Kenya	NO	Norway	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NZ	New Zealand	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	PL	Poland		
CM	Cameroon	KR	Republic of Korea	PT	Portugal		
CN	China	KZ	Kazakhstan	RO	Romania		
CU	Cuba	LC	Saint Lucia	RU	Russian Federation		
CZ	Czech Republic	LI	Liechtenstein	SD	Sudan		
DE	Germany	LK	Sri Lanka	SE	Sweden		
DK	Denmark	LR	Liberia	SG	Singapore		
EE	Estonia						

VALVE TRAIN ASSEMBLY

The present invention relates to a valve train assembly for an internal combustion engine, and to rocker arms for such an assembly. The invention is particularly but not exclusively related to arrangements in which the number of parts in the assembly is reduced, in which various parts can be pre-assembled to facilitate engine assembly, and in which various parts are made more simply.

Various aspects of the invention are intended to deal with a number of separate problems in existing arrangements. For example, internal combustion engines which have a plurality of valves for each cylinder tend to use rocker arms which are mounted on a common pivot or axle and which therefore need to have differing lengths in order to match the differing positions of the valves. It is therefore necessary to manufacture two different types of rocker arms.

It is also common, particularly for centre-pivoted rocker arms, to have an hydraulic lash compensation device mounted at the valve end of the rocker arm, the device therefore being continually reciprocated. This requires a complex machined oil distribution path and makes it more difficult to feed oil to the lash adjuster. Furthermore, the components of the rocker arm are heavy and therefore strong valve return springs are required, and the rocker shaft has

to be strong and therefore of large diameter, and heat-treated to harden the surface in order to resist wear.

Various aspects of the present invention are set out in the accompanying claims.

5 In a preferred embodiment, a valve train assembly for a internal combustion engine comprises a valve train carrier having a plurality of individual rocker arm fulcra, and a rocker arm attached to each fulcrum. The carrier may also have one or more camshafts mounted thereto.

10 Such an arrangement can be provided as a pre-assembled unit for fitting to a cylinder head having valves mounted therein, thus substantially facilitating the assembly of an engine.

15 Each fulcrum may form part of a hydraulic lash adjuster. Accordingly, since the lash adjusters would be fixedly mounted to the carrier, they are more easily supplied with oil, so that a smaller oil pump producing relatively low pressure can be used.

20 In a particularly advantageous arrangement, each rocker arm and its associated fulcrum have co-operating part-spherical surfaces which permit not only the pivoting motion required for operating the valves, but also a degree of rotation about the length of the rocker arm, to provide a self-adjusting function. Preferably, the rocker arm has a part-spherical recess into which a part-spherical projection is located. (In practice the profile of the recess may comprise several, e.g. three, spherical segments of slightly different diameter

tangential to each other, sometimes referred to as a gothic socket.) The rocker arm may be attached to the projection by means of a clip, possibly made of spring steel, which is fitted over the head of the projection. As the rocker arms do not need to be fitted to rocker axles, they may be made smaller and 5 lighter compared to existing aluminium or steel rockers. In a preferred embodiment, the rockers are made of pressed sheet metal (with the final thickness possibly increased or decreased by the pressing operation to provide suitable weight/strength properties), and their lightness enables the use of lighter valve springs resulting in lower energy consumption.

10 Because of the self-adjusting arrangement mentioned above, it is possible to arrange for contact between a driving cam and the rocker arm to extend laterally over a large distance, for example by having mounted on the rocker a roller with a wide surface which is flat in a direction parallel to the roller axis. This provides a greater area of contact than existing rockers which 15 rotate about an axle, and which need a roller having a convex surface to ensure proper contact. As a result of the reduction in stress by increasing the area of contact, the camshaft need not be so strong, and indeed it is possible to use cast iron instead of more expensive steel.

By appropriate positioning of the individual rocker arm fulcra, it is 20 possible to use rockers of equal length for all the valves. Accordingly, the rockers can be substantially identical, thereby reducing manufacturing costs.

Arrangements embodying the invention will now be described by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a side view of a prior art rocker arm;

Fig. 2 is a side view, partly in section, of a rocker arm arrangement according to the invention applied to a valve;

Fig. 3 is a side view of the rocker arm of Figure 2;

Fig. 4 is a plan view of the rocker arm shown in Fig. 3;

Fig. 5 is a section along the line V-V of Fig. 3;

Fig. 6 shows is a section along the line VI-VI in Fig. 3;

Fig. 7 is a section through a hydraulic tappet forming a fulcrum of the rocker arm;

Fig. 8 is a transverse section showing a valve train carrier of the present invention, for controlling two rows of valves with a single central camshaft;

Fig. 9 is a plan view of the valve train carrier as shown in Fig. 7;

Fig. 10 is a side view showing another embodiment of a valve train assembly in accordance with the invention; and

Fig. 11 is a perspective view, from below, of a valve train carrier of the assembly of Fig. 10.

Fig. 1 shows a prior art rocker (B) made of pressed aluminium, and comprising a lever of the first order mounted on a fixed axle (70), which also carries other rockers arranged in a row. One end of the rocker (B) is in

contact with a cam (C) by means of a roller (R'), while the other end has a reciprocating and pivoting hydraulic lash adjuster, referred to also as a tappet (80). The tappet has a spigot or projection (81) at the base acting on the head of a valve (V). A double row of camshafts (A') acts on convex surfaces of 5 rollers (R').

Fig. 2 shows an example of a rocker arm arrangement according to the present invention.

The rocker (B) of the present invention is again a lever of the first order, i.e. it is a centre-pivoted rocker arm. However, the rocker (B) is 10 mounted on a tappet (4) placed between a first end of the rocker (B), which is fitted with a roller (R) displaced and pushed against a cam (C) on the camshaft, and a second end, which transmits the pressure to open the poppet valve (V) against the resilient force of a spring (M).

The rocker (B) shown in Figs. 3 to 6 is made up of two lateral flanges 15 (12) and (12'), linked by an upper plate (13), with which it forms a U-shaped section, and is formed by bending or stamping a sheet of steel.

In the process of pressing the rocker from sheet steel, a hemispherical recess (14) is formed in the plate (13), suitable for mating with the hemispherical head (41) of a spigot or projection (42) which is part of a lash 20 adjuster or tappet (4). The tappet (4) is fitted in its own fixed seat (45, Fig. 7) formed by boring an aluminium cover (L) of the engine head. The cover (L) constitutes a valve train carrier, and is discussed further below.

Because of the co-operation of the part-spherical surfaces of the recess (14) and the end (41) of the spigot (42) this spigot forms a fulcrum about which the rocker arm (B) can reciprocate in order to operate the valve (V), and around which the rocker arm may be laterally turned. It will be noted in 5 particular that the rocker arm can rotate about an axis X (Fig. 4) and about the axis of the spigot (42), to provide a degree of self-adjustment for the purposes set out below.

Rocker (B) comprises at one end a transverse opening (15) into which a pivoting trunnion (16) is fitted, the trunnion (16) having opposing recesses 10 (17), one of which presses onto the head of the stem of the valve (V), adjusting itself in accordance with the relative movement of the rocker arm (B) of the valve shaft, which may vary depending on the type of engine.

At the other end is fitted roller (R) having needle bearings and located on an axle (20) extending through openings (22) provided in flanges (12) and 15 (12').

Roller (R) is very simple, with a straight cylindrical outside surface which closely fits the outside surface of cam (C) since as described above the rocker, with its fulcrum on the hemispherical recess (14), automatically compensates for any imperfection in transverse movement, thus making a 20 convex outside surface, as required in customary design, unnecessary.

In order to keep the trunnion (16) fixed in place at the first end of the rocker, a resilient sheet (25) is used with flanges (26) folded back on

themselves so that the lower section can be attached to the rocker flanges (see Fig. 5). The resilient sheet has an inlet (27) at the top for the purpose of lubricating the trunnion (16).

A second resilient sheet (30), with flanges (31) folded back on 5 themselves, is fitted over the hemispherical recess (14) to restrict relative transverse movement of the spigot (42) of tappet (4). The sheet (30) may be made of spring steel, and has an aperture which allows the rocker arm (B) to be easily snap-fitted over the head (41) of the spigot (42) and thus attached to the cover (L). The sheet (30) thus retains the rocker arm (B) on the cover (L) 10 without inhibiting any intended operational movement of the rocker arm.

In this embodiment, the projection or spigot (42) has a relatively narrow neck leading to the enlarged, part-spherical head (41), so that the aperture in the sheet (30), which has a diameter slightly larger than that of the neck, can be used to hold the rocker arm in place. Preferably, as shown in 15 Fig. 4, the aperture is elongate, with its longitudinal axis extended substantially parallel to the length of the rocker arm, so as to facilitate fitting the rocker arm to the tappet (4), and to permit a degree of freedom of movement in the longitudinal direction to ensure proper engagement with the cam shaft and valve. However, alternative arrangements are possible. For 20 example, the rocker arm could be fastened to the head (41) by means of a rivet or other member extending through the rocker arm into a recess at the end of the head (41), possibly engaging therein by means of a screw thread or by a

resilient enlarged portion which engages in an annular ridge within the recess.

In any event, it is desired that the means attaching the rocker arm to the fulcrum be fairly loose, and arranged so as not to inhibit the intended operational movement of the rocker arm.

5 Fig. 7 is a detailed view of the tappet (4), which keeps rocker (B) pressed against one end of the valve head (V) by means of the pivoting trunnion (16), and at the other end against the cam (C) by means of roller (R). The spigot (42), carrying the hemispherical head (41) which forms the rocker fulcrum, forms a plunger which is attached to a chamber (43) which slides in a sleeve (44) inserted precisely into the seat (45) formed by boring in the cover (L) of the engine block. Within the lower part of the chamber (43) is a high pressure tappet chamber (47), whilst above is a plunger (48) which houses a low-pressure oil reservoir (49). The oil is supplied through the inlet (50) and channels (51) in the cover (L).

10

15 Inlets (46) and (46') are provided in the spigot (42) for the purpose of lubricating the hemispherical end (41) which acts as the fulcrum.

By way of example, Figs. 8 and 9 show from the side and from above, respectively, the arrangement of a valve control train using rockers (B1), (B2), ... as described above, for operating valves V1, V2, ... in an internal 20 combustion engine with a single central camshaft (A).

Using such an arrangement facilitates the assembly of an engine. The engine cylinder head has a lower head part (80) into which the valves (V1)

and (V2) are installed. Their springs (M) are located in recesses (60) of the lower head (80).

In a separate operation, the valve train carrier formed by the cover (L) has fitted thereto the rocker arms (B1) and (B2), together with any other 5 rocker arms required for the engine (see Fig. 9). This therefore forms a self-supporting assembly which can be manufactured and sold separately from the rest of the engine and provided in a pre-assembled state ready for fitting to the engine. Thus, not only is the overall assembly facilitated by pre-assembling the valve carrier, but the individual fitting of the rocker arms can be carried 10 out as a separate operation, so the final assembly of the engine is significantly simpler.

If desired, a manufacturer can supply different versions of the valve carrier, all for fitting to the same engine head, but made to different specifications. For example, one version may have hydraulic lash adjusters 15 and rocker arms provided with rollers, and another, less-expensive one may have mechanical lash adjusters and a fixed cam-engaging surface on the rocker arms rather than rollers. This facilitates the production of different types of engines, suited to the customer, while still enabling a simple assembly procedure.

20 The location of the respective fulcra on the cover (L) can be selected such that all the rocker arms may have the same length, and therefore can if desired be constructed identically.

Preferably, the camshaft is also fitted to the cover (L) during pre-assembly.

Figs. 10 and 11, in which like reference signs represent like integers, show an alternative embodiment of the invention, in which twin camshafts 5 (A1, A2) drive respective rows of rocker arms (B). The aluminium valve train carrier (L) is best illustrated in Fig. 11, which shows identical rocker arms (B) mounted in two lines, the arms within each line being positioned in a staggered arrangement so that they are suitably located for driving the inlet and outlet exhaust valves. Although not shown in Fig. 11, the camshafts (A1, 10 A2) are also preferably mounted to the carrier (L) before the entire assembly is fitted to the lower cylinder head of the engine.

The carriers (L) of either embodiment may have channels for distributing oil to the valve trains; indeed, all the required oil channels may be located in the carrier.

CLAIMS:

1. A valve train assembly for an internal combustion engine, the assembly comprising a valve train carrier having a plurality of individual rocker arm fulcra and a rocker arm attachable to each fulcrum.

5

2. An assembly as claimed in claim 1, wherein each fulcrum forms part of a lash adjuster.

10 3. An assembly as claimed in claim 2, wherein each lash adjuster is an hydraulic lash adjuster.

4. An assembly as claimed in any preceding claim, wherein each rocker arm constitutes a lever of the first order.

15 5. An assembly as claimed in any preceding claim, wherein each rocker arm has a part-spherical surface for mating with a corresponding surface of the fulcrum to which it is attached.

20 6. An assembly as claimed in any preceding claim, wherein each rocker arm has been formed by deformation of a sheet.

7. An assembly as claimed in any one claims 1 to 4, wherein each rocker arm has been formed by deformation of a sheet, said deformation also forming a part-spherical surface for mating with a corresponding surface of the fulcrum to which the rocker arm is attached.

8. An assembly as claimed in any preceding claim, wherein the rocker arms are all of substantially the same length.

9. An assembly as claimed in claim 8, wherein the rocker arms
10. are substantially identical.

10. An assembly as claimed in any preceding claim, wherein each rocker arm is provided with a resilient apertured member for fitting over the associated fulcrum in order to attach the rocker arm to the fulcrum.

11. An assembly as claimed in any preceding claim, the assembly also having mounted thereto at least one camshaft.

12. An assembly as claimed in any preceding claim, the carrier
20 having formed therein channels for conveying oil to the fulcra.

13. An assembly as claimed in any preceding claim, wherein each rocker arm carries a roller for engagement with a cam of a camshaft, and wherein each roller has a substantially flat cylindrical outer surface.

5 14. An assembly as claimed in any preceding claim, the carrier supporting rocker arms for inlet and exhaust valves for a plurality of cylinders.

10 15. An internal combustion engine having a valve train assembly as claimed in any preceding claim, the engine comprising a plurality of cylinders each having inlet and exhaust valves, said carrier supporting rocker arms for said inlet and exhaust valves.

16. A method of assembling an internal combustion engine, the
15 method comprising:

- (a) providing a valve train carrier having a plurality of individual rocker arm fulcra;
- (b) attaching a rocker arm to each fulcrum; and
- (c) mounting the carrier with the attached rocker arms on a cylinder head such that each rocker arm is brought into functional relationship with a respective engine valve.

17. A method as claimed in claim 16, the method including the step of mounting at least one camshaft to the carrier before mounting the carrier on the cylinder head.

5 18. A method as claimed in claim 16 or claim 17, wherein each rocker arm is mounted to a respective fulcrum by means of an apertured sheet which is snapped-fitted over the fulcrum.

19. A rocker arm for an internal combustion engine, the rocker arm having a part-spherical surface for mating with a corresponding surface of a fulcrum which is arranged to permit reciprocation of the rocker arm in order to operate a valve, the rocker arm further comprising means for attaching the arm to the fulcrum.

15 20. A rocker arm as claimed in claim 19, wherein the rocker arm is channel-shaped in section and has been formed by deformation of a sheet.

21. A rocker arm as claimed in claim 20, wherein the part-spherical surface of the rocker arm has been formed by deformation of said 20 sheet.

22. A rocker arm as claimed in any one of claims 19 to 21, wherein the attaching means comprises a resilient, apertured member for fitting over the fulcrum.

5 23. A rocker arm as claimed in any one of claims 19 to 22, the rocker arm having a roller for engagement with a cam of a camshaft, the roller having a substantially flat cylindrical surface.

10 24. A valve train assembly for an internal combustion engine, the assembly comprising a plurality of rocker arms each arranged for pivoting about a respective fulcrum, the rocker arms being of substantially equal length.

15 25. An assembly as claimed in claim 24, including a common carrier supporting the rocker arms by means of said fulcra.

26. An assembly as claimed in claim 24 or claim 25, wherein each fulcrum forms part of a lash adjuster.

117

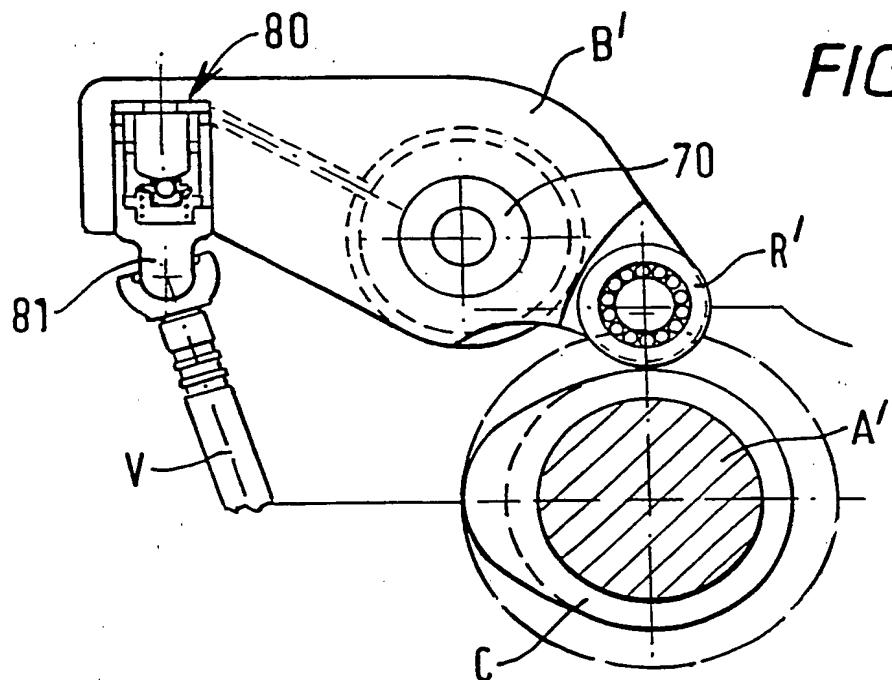
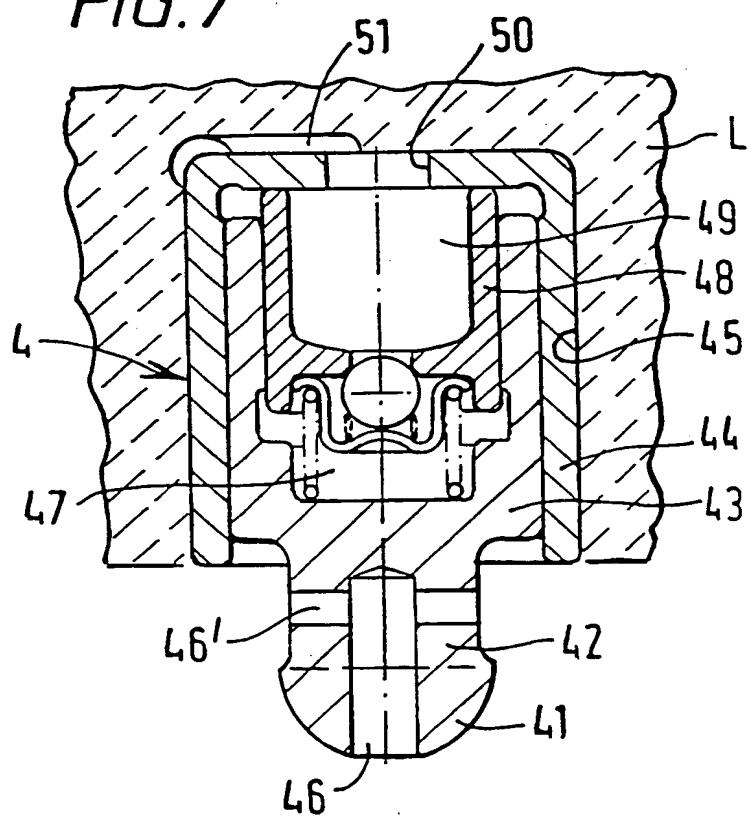


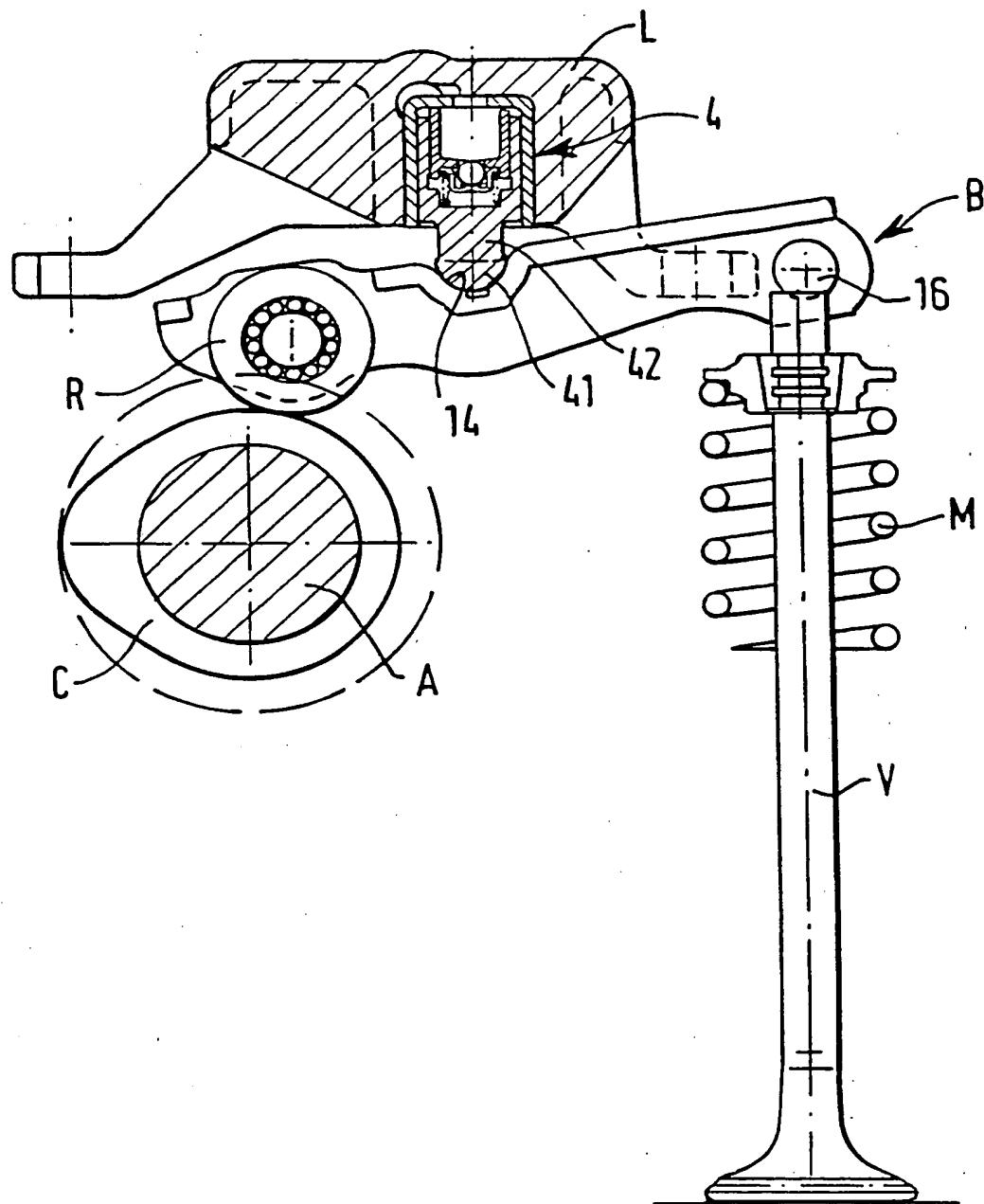
FIG. 7



SUBSTITUTE SHEET (RULE 26)

2/7

FIG. 2



SUBSTITUTE SHEET (RULE 26)

3/7

FIG.3

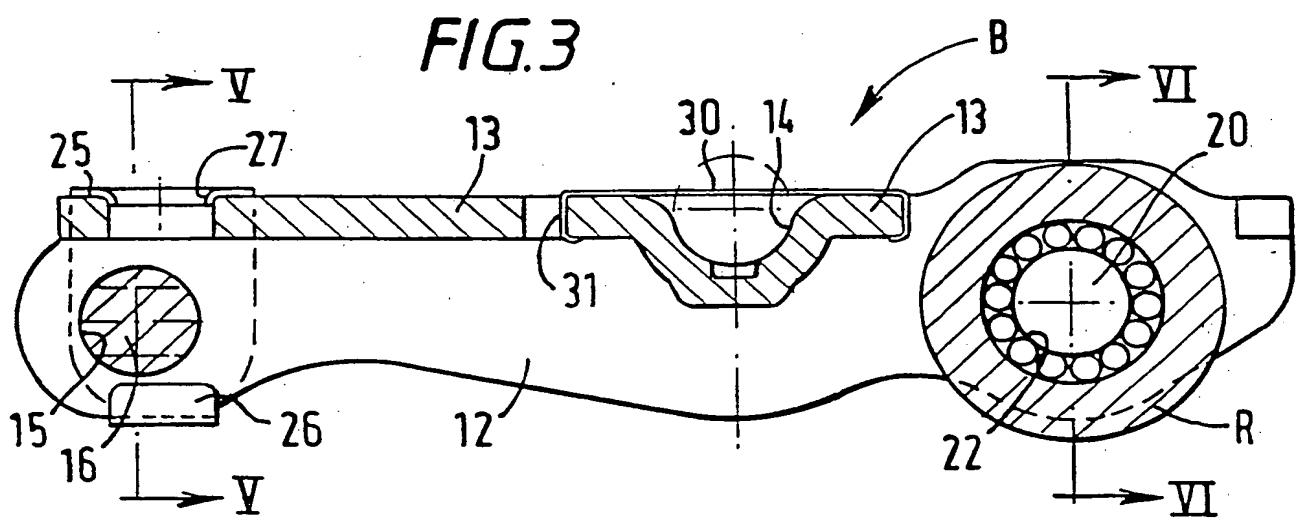


FIG.4

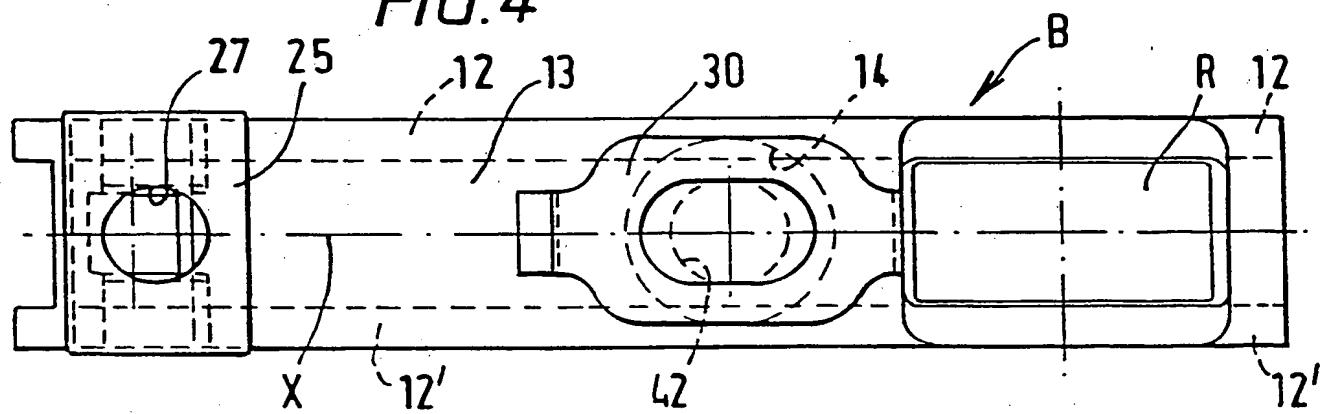


FIG.5

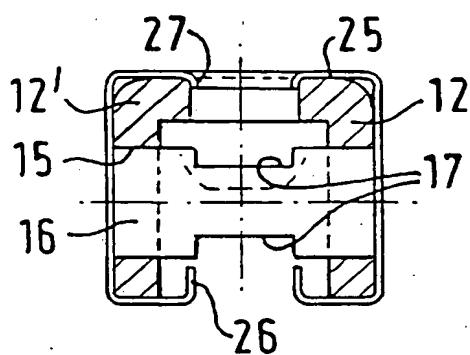
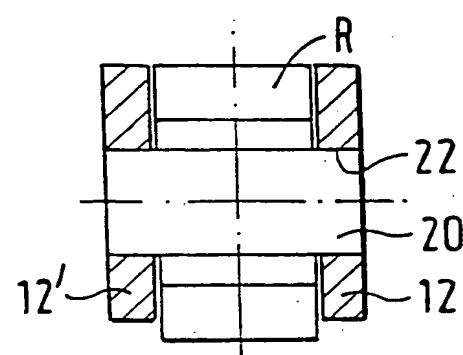


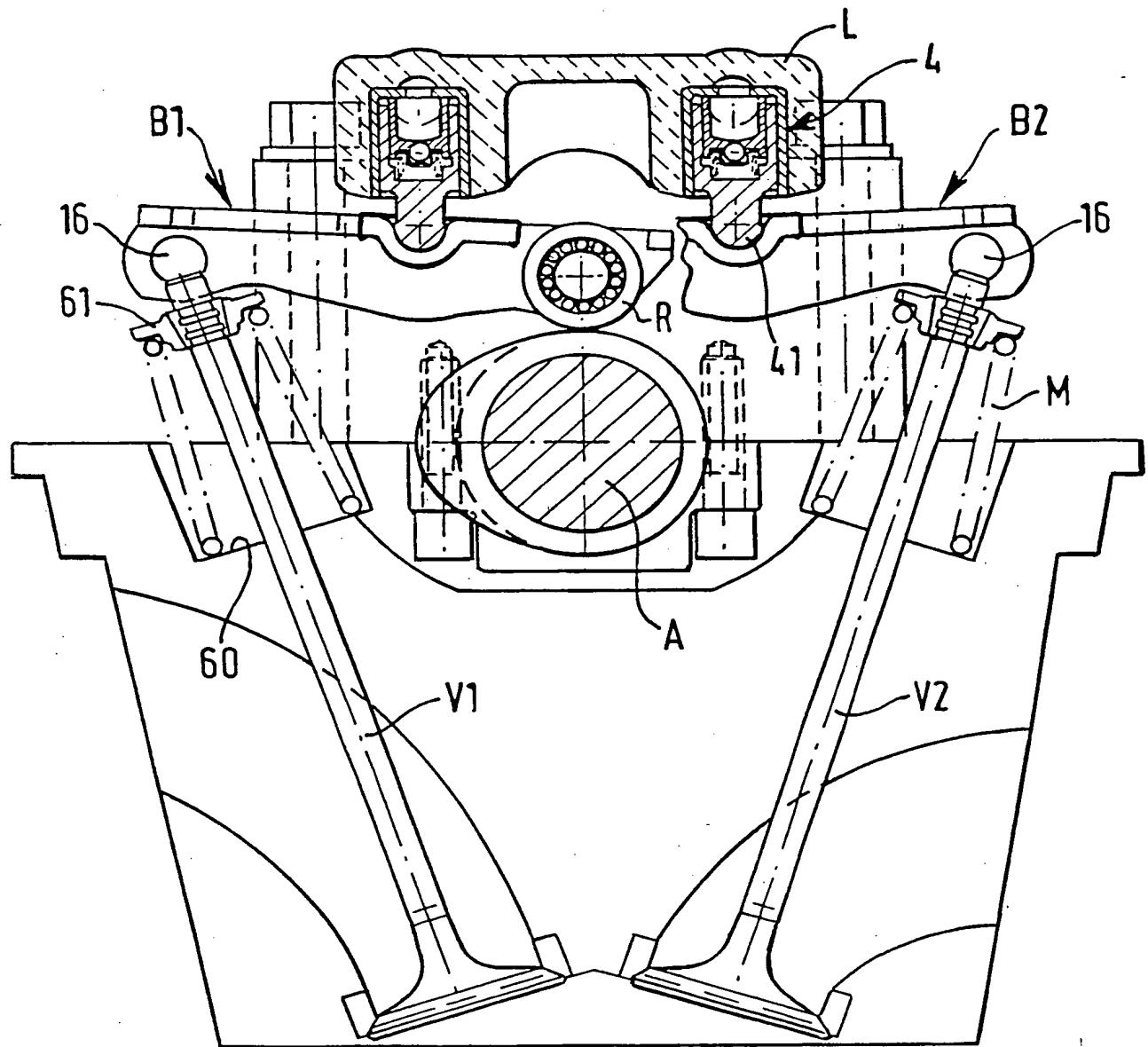
FIG.6



SUBSTITUTE SHEET (RULE 26)

4/7

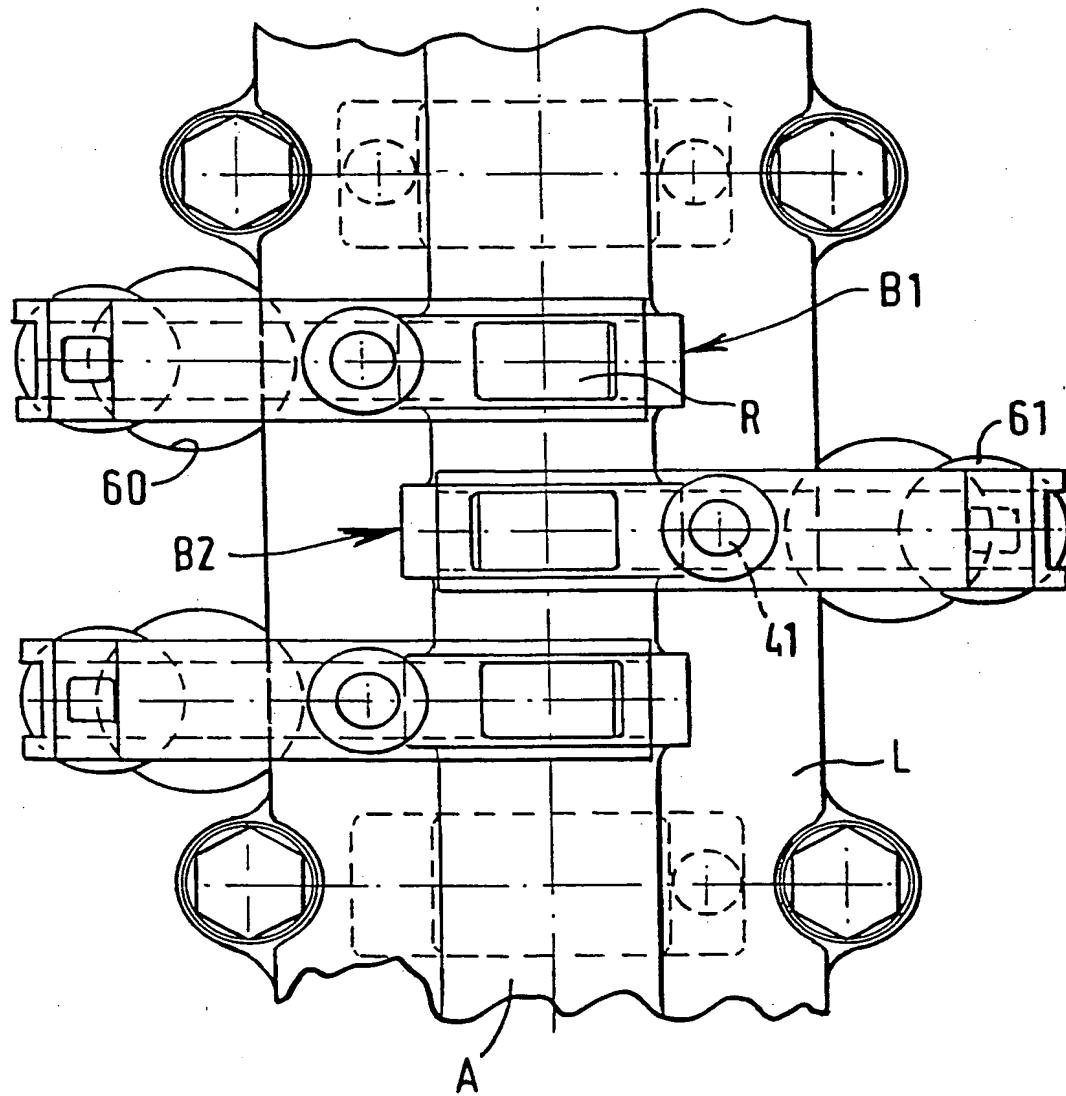
FIG. 8



SUBSTITUTE SHEET (RULE 26)

5/7

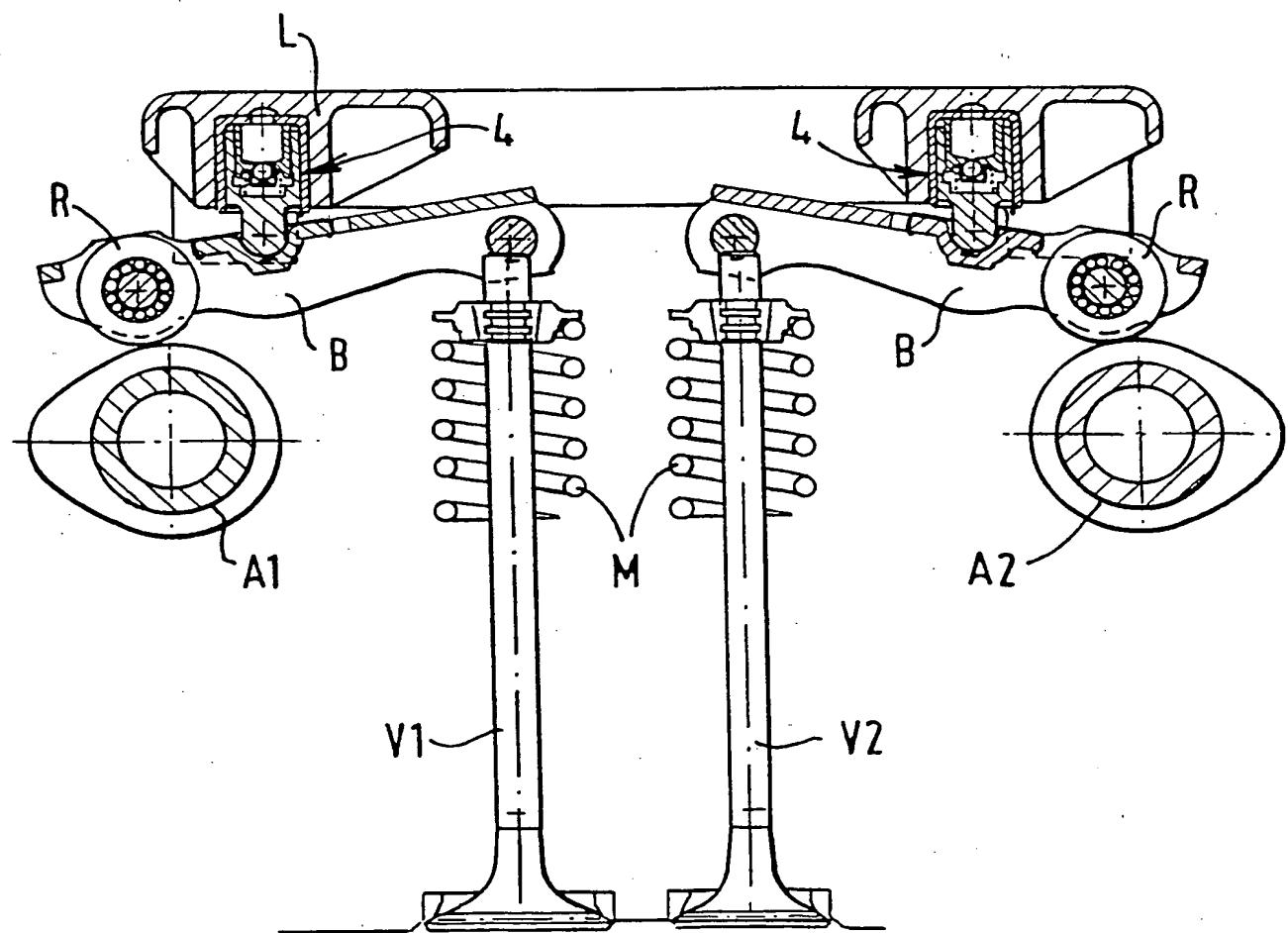
FIG. 9



SUBSTITUTE SHEET (RULE 26)

6/7

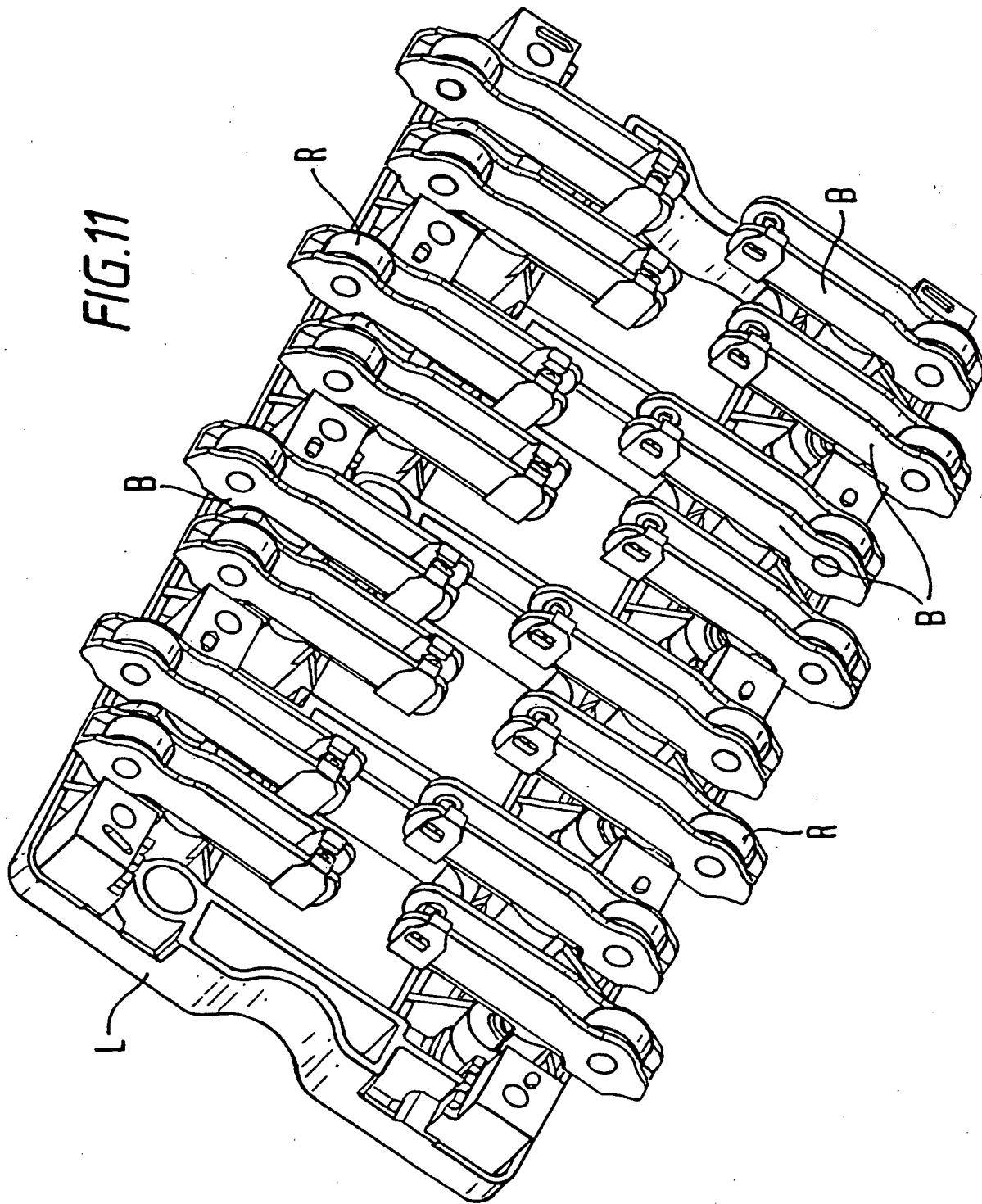
FIG. 10



SUBSTITUTE SHEET (RULE 26)

7/7

FIG.11



SUBSTITUTE SHEET (RULE 26)

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IB 99/01699A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 F01L1/24 F01L1/18 F01L1/053

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 F01L

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the International search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	PATENT ABSTRACTS OF JAPAN vol. 7, no. 187, 16 August 1983 (1983-08-16) & JP 58 088412 A (HONDA GIKEN KOGYO KK), 26 May 1983 (1983-05-26) abstract; figures	1-5, 8, 9, 12, 14, 15, 24-26
A	US 4 913 104 A (HENLEY MFG CORP) 3 April 1999 (1999-04-03)	11, 16, 19
X	the whole document	1-7, 13-15, 19-21, 23-26
X	US 4 682 575 A (FORD MOTOR COMPANY) 28 July 1987 (1987-07-28)	1-4, 6, 7, 12-15, 24, 25
A	the whole document	16 -/-

 Further documents are listed in the continuation of box C. Patent family members are listed in annex.

* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier document but published on or after the International filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the International filing date but later than the priority date claimed

"T" later document published after the International filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the Invention

"X" document of particular relevance; the claimed Invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed Invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the International search

15 February 2000

Date of mailing of the International search report

22/02/2000

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
Fax (+31-70) 340-3016

Authorized officer

Klinger, T

1

INTERNATIONAL SEARCH REPORT

Int'l. Application No
PCT/IB 99/01699

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 4 762 099 A (HONDA MOTOR CO LTD) 9 August 1998 (1998-08-09) column 2, line 60 -column 5, line 25 figures 1-7 —	1,10
A	GB 143 898 A (DAIMLER MOTOREN) 31 May 1921 (1921-05-31) the whole document —	1,11
X	DE 12 60 864 B (PORSCHE KG) 8 February 1968 (1968-02-08) —	1-5, 8-11, 14-19, 24-26
A	column 2, line 37 -column 3, line 7 figures —	6,11

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int. Application No
PCT/IB 99/01699

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
JP 58088412	A 26-05-1983	JP 1014404	B	10-03-1989
		JP 1527631	C	30-10-1989
US 4913104	A 03-04-1990	CA	2001464	A 31-05-1990
US 4682575	A 28-07-1987	DE	3709882	A 01-10-1987
		GB	2188677	A, B 07-10-1987
		JP	62233409	A 13-10-1987
US 4762099	A 09-08-1988	JP	63016109	A 23-01-1988
		JP	63018117	A 26-01-1988
		GB	2193997	A, B 24-02-1988
GB 143898	A	NONE		
DE 1260864	B	NONE		

**This Page is Inserted by IFW Indexing and Scanning
Operations and is not part of the Official Record**

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images include but are not limited to the items checked:

- BLACK BORDERS**
- IMAGE CUT OFF AT TOP, BOTTOM OR SIDES**
- FADED TEXT OR DRAWING**
- BLURRED OR ILLEGIBLE TEXT OR DRAWING**
- SKEWED/SLANTED IMAGES**
- COLOR OR BLACK AND WHITE PHOTOGRAPHS**
- GRAY SCALE DOCUMENTS**
- LINES OR MARKS ON ORIGINAL DOCUMENT**
- REFERENCE(S) OR EXHIBIT(S) SUBMITTED ARE POOR QUALITY**
- OTHER:** _____

IMAGES ARE BEST AVAILABLE COPY.

As rescanning these documents will not correct the image problems checked, please do not report these problems to the IFW Image Problem Mailbox.